

# Findings of the NCHRP 9-47A Engineering Properties and Performance of WMA Technologies

Global Warm Mix Asphalt Workshop

Coralville, Iowa

October 31, 2013

# Outline

- Projects Evaluated
- Engineering Properties
- Field Performance
- Summary of Findings

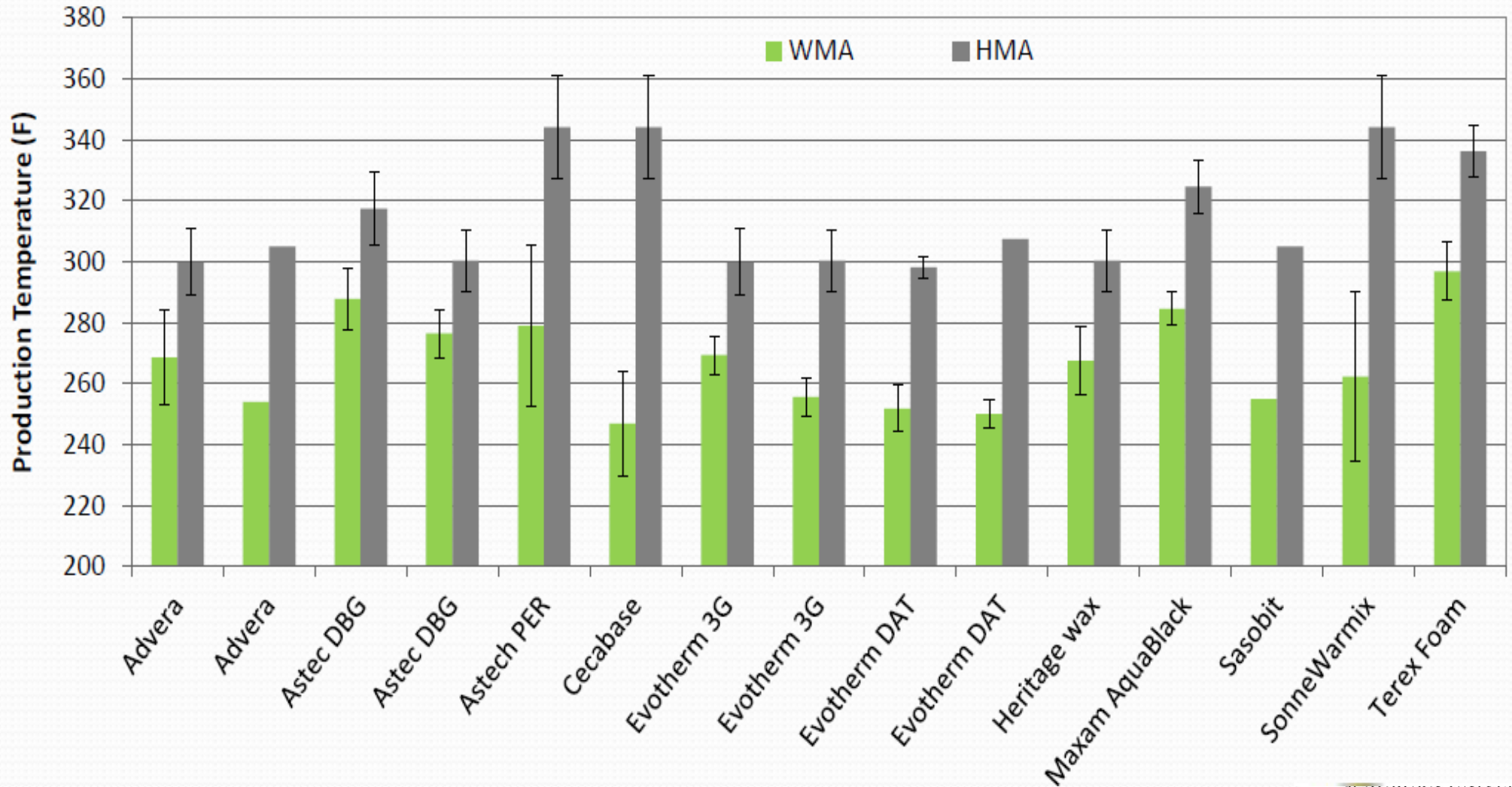
# NCHRP 9-47A Projects

Location	Route	WMA Technologies	Date Const.
St. Louis, MO	Hall Street	Evotherm ET, Sasobit, Aspha-min	May-2006
Iron Mtn., MI	M95	Sasobit	Sep-2006
Silverthorne, CO	I-70	Advera, Sasobit, Evotherm DAT	Aug-2007
Franklin, TN	SR45	Astec DBG, Advera, Evotherm DAT, Sasobit	Oct-2007
Graham, TX	US 380	Astec DBG	Jun-2008
George, WA	I-90	Sasobit	Jun-2008
Walla Walla, WA	US-12	Maxam Aquablack	Apr-2010
Centreville, VA	I-66	Astec DBG	Jun-2010
Rapid River, MI	CR-513	Evotherm 3G, and Advera	Jun-2010
Baker, MT	Route 322	Evotherm DAT	Aug-2010
Munster, IN	Calumet Ave.	Evotherm, Gencor foam, Heritage wax	Sep-2010
Jeff. Co., FL,	SR 30	Terex foaming system	Oct-2010
Queens, NY	Little Neck Pkwy	Cecabase, SonneWarmix, BituTech PER	Oct-2010
Case Grande, AZ	SR 84	Sasobit	Dec-2011

# NCHRP 9-47 A Projects

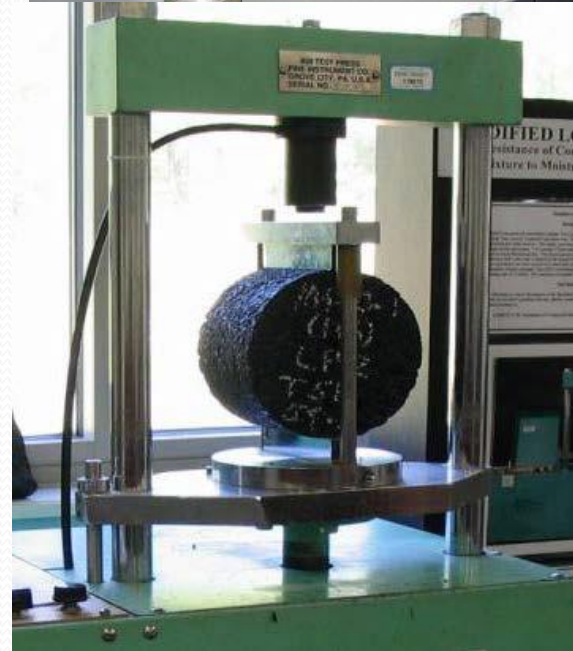
Location	Route	N-Design	NMAS	Virgin PG	Virgin Aggregate	RAP %
St. Louis, MO	Hall Street	100	12.5	76-22	Limestone	10
Iron Mtn., MI	M95	86	9.5	58-34	Basalt	0
Silverthorne, CO	I-70	75	12.5	58-28	River Rock	0
Franklin, TN	SR45	75-blow	12.5	70-22	Limestone	0
Graham, TX	US 380	75	9.5	70-22	Limestone	0
George, WA	I-90	100	12.5	76-28	Basalt	20
Walla Walla, WA	US-12	100	12.5	64-28	Basalt	20
Centreville, VA	I-66	65	12.5	76-22	Limestone	15
Rapid River, MI	CR-513	30*	12.5	52-34	Gravel	17
Baker, MT	Route 322	75	19.0	64-28	Gravel	0
Munster, IN	Calumet Ave.	75	9.5	64-22	Limestone	15
Jeff. Co., FL	SR 30	75	12.5	76-22	Granite	15
Queens, NY	Little Neck Pkwy	75	12.5	64-22	Traprock	20
Case Grande, AZ	SR 84	75-blow	19.0	70-10	Gravel	12

# NCHRP 9-47A Production Temperatures



# Engineering Properties

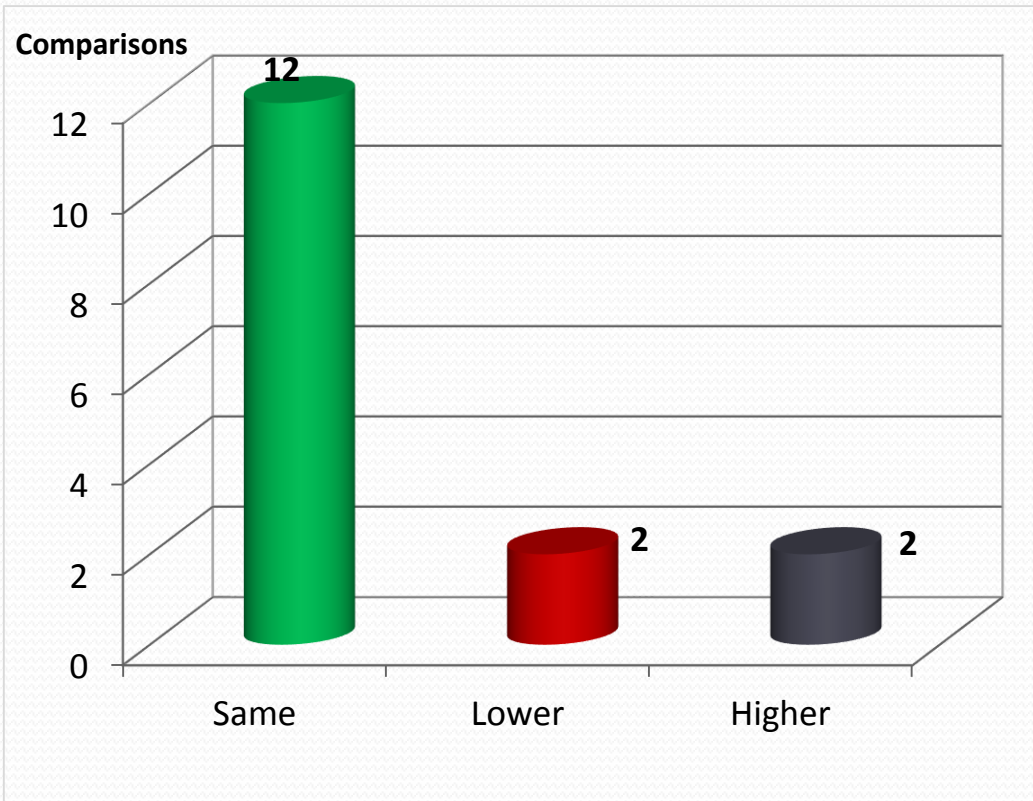
- True Binder Grades
- In Place Densities
- Core tensile strengths
- TSR
- Hamburg
- FN
- $E^*$



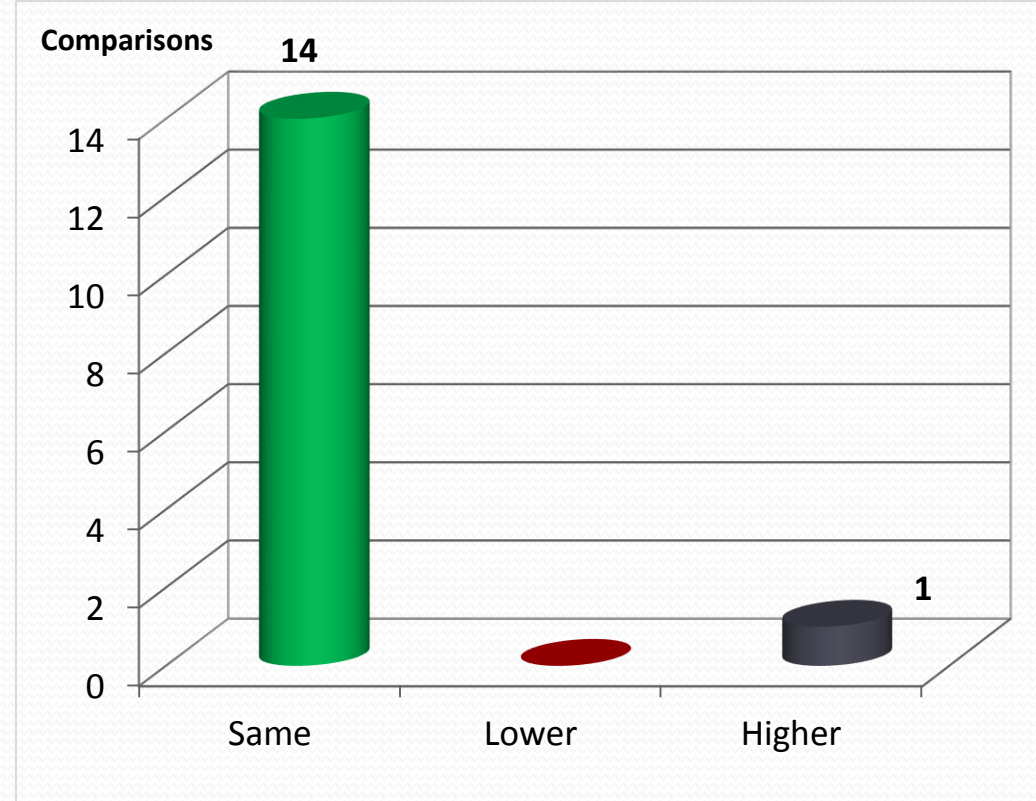
# True Binder Grades Differences (WMA-HMA) (Mix Sampled During Construction)

Location	WMA	Construction	
		$\Delta$ High Temp	$\Delta$ Low Temp
Walla Walla, WA	Aquablack	-2.6	-1.9
Centerville, VA	Astec DBG	1.2	-1.8
Rapid River, MI	Evotherm 3G	-0.9	0.4
	Advera	0.7	0
Baker, MT	Evotherm DAT	-0.1	0.4
Munster, IN	Evotherm 3G	-2.7	-2.2
	Gencor Ultrafoam	-4.2	-1.8
	Heritage Wax	-2.1	0.6
Jefferson CO, FL	Terex CMI Foam	-2.1	0.6
New York, NY	Cecabase	-5.7	-4.8
	SonneWarmix	-4.5	-3.3
	BituTech PER	-5.3	-3.5
Casa Grande, AZ	Sasobit	-2.0	0.6
<b>Average</b>		<b>-2.3</b>	<b>-1.3</b>
<b>Maximum T<sub>emp</sub> Difference</b>		<b>-5.7</b>	<b>-4.8</b>
<b>Minimum T<sub>emp</sub> Difference</b>		<b>1.2</b>	<b>0.6</b>

# In Place Densities (=)



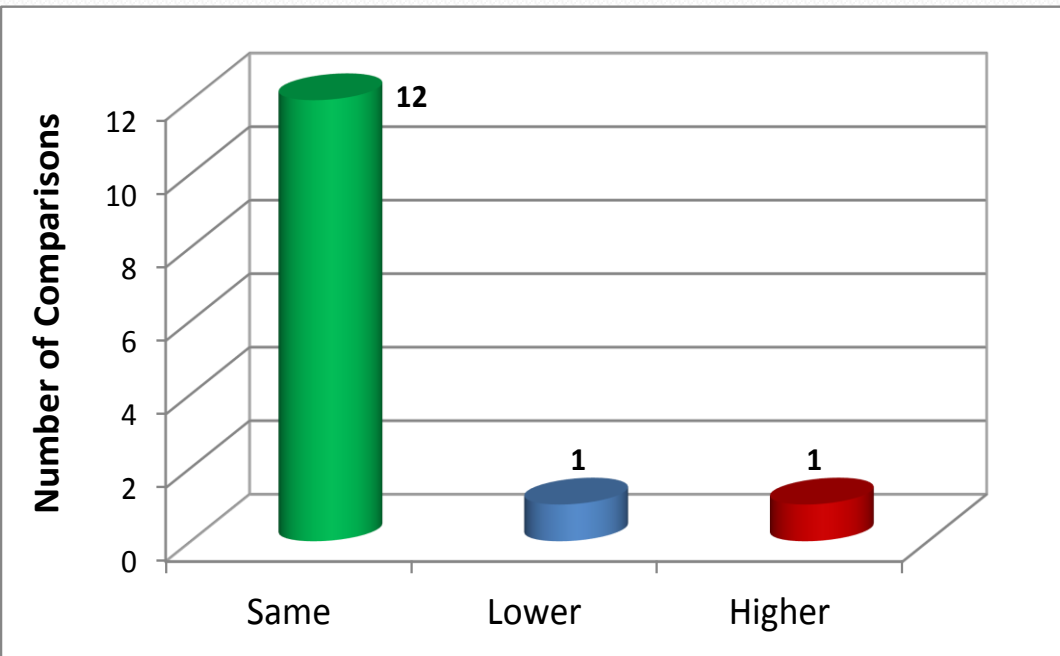
*After Construction*



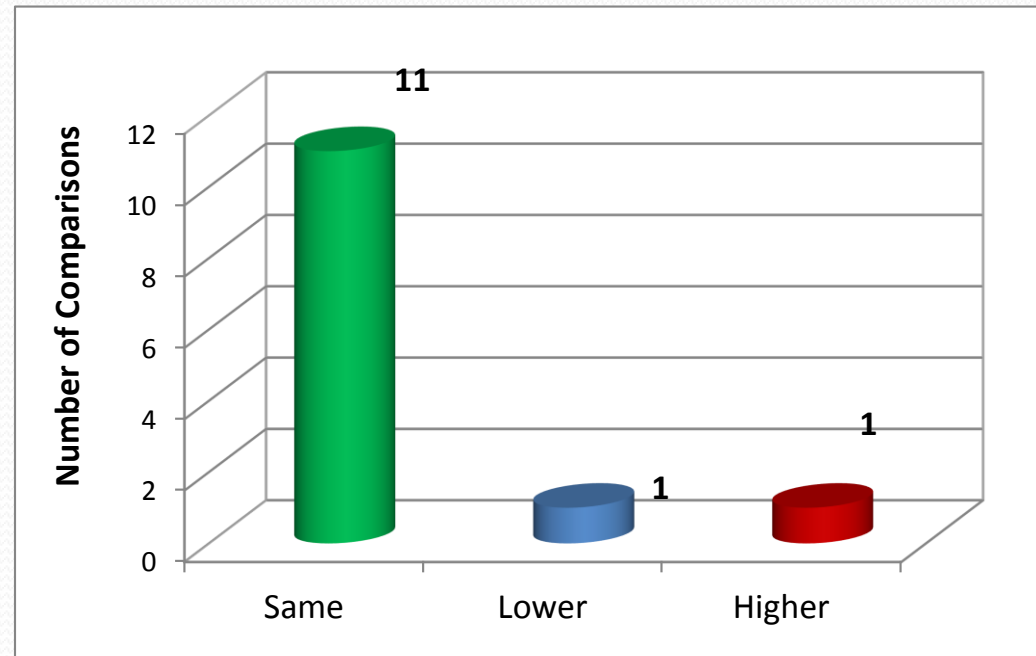
*After ~2 Years*



# Core Tensile Strength (=)

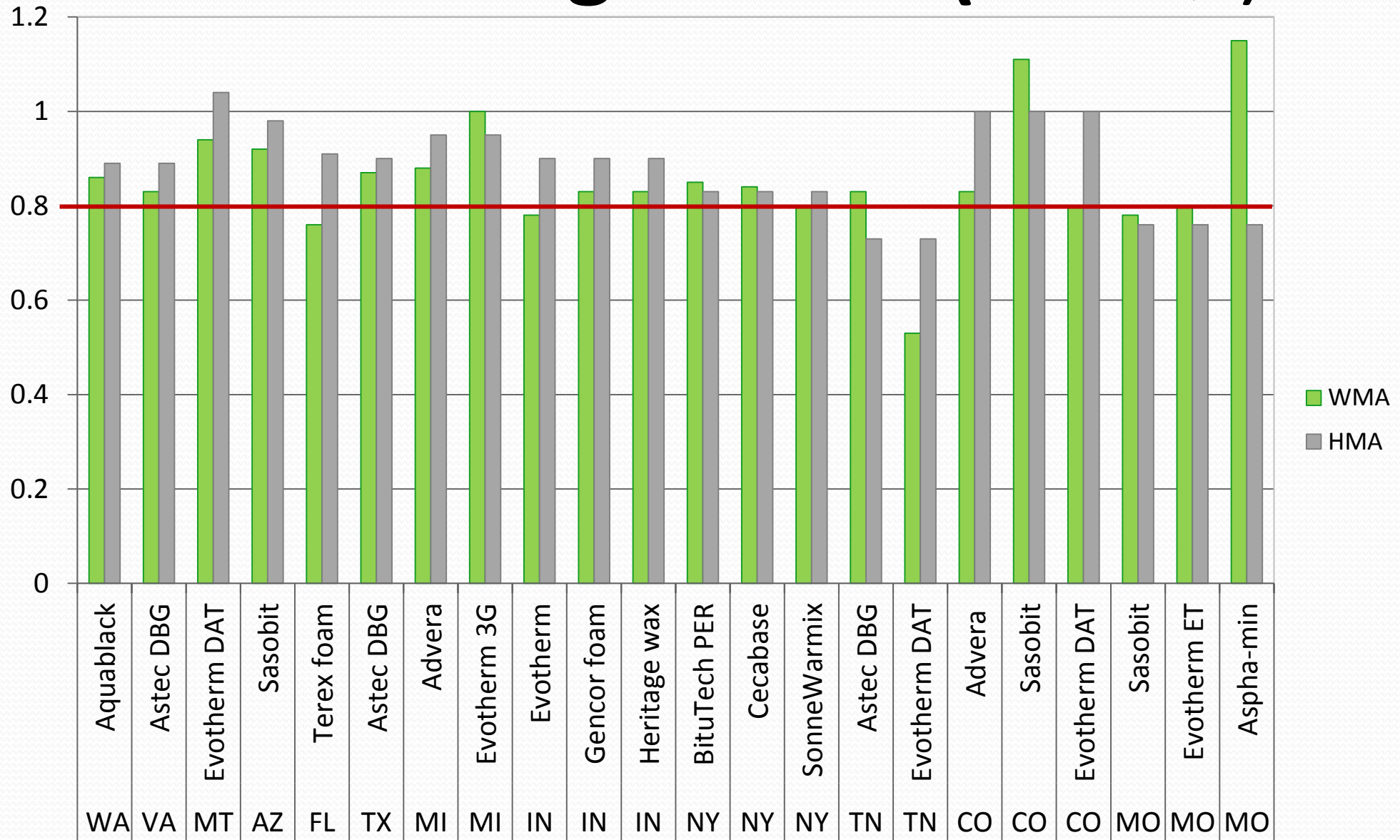


*After Construction*



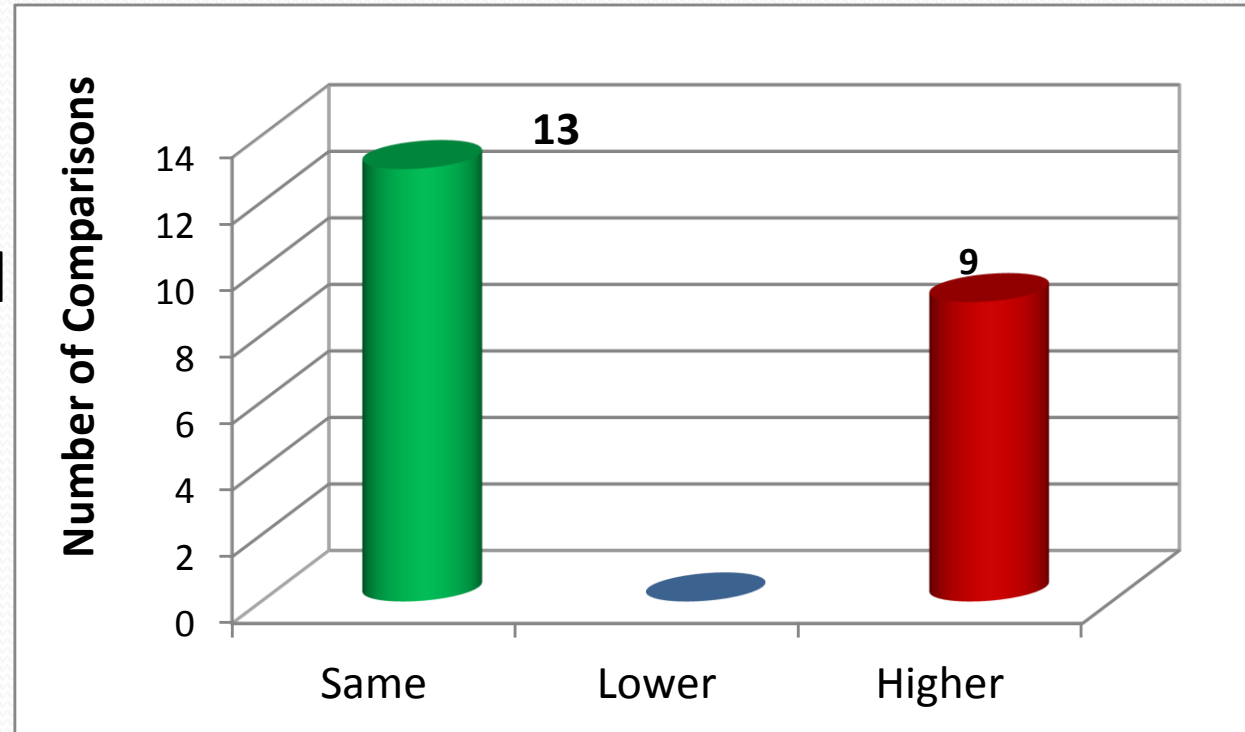
*After ~2 Years*

# Tensile Strength Ratio (= or ↓)



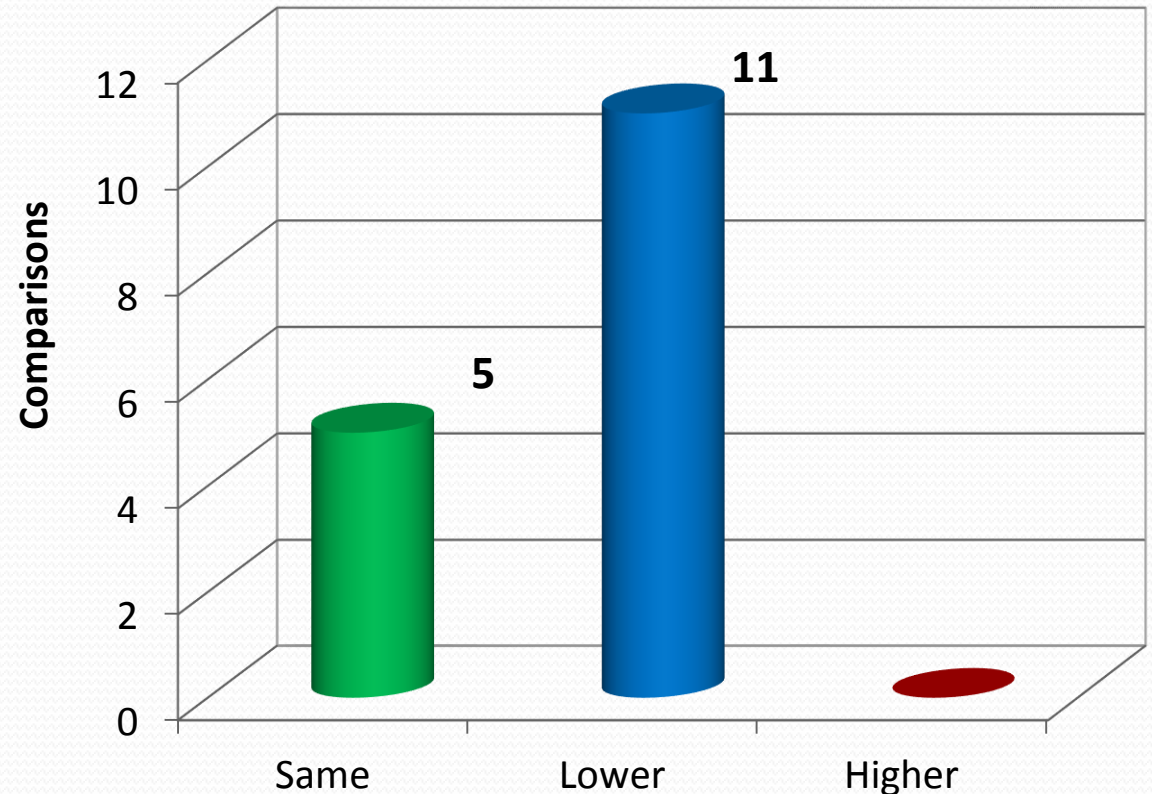
# Hamburg (= or ↓)

- AASHTO T 324
- All Hamburg specimens fabricated in the field
- Specimens conditioned and tested in a 50°C water bath
- Submerged specimens subjected to 10,000 cycles (20,000 passes) of wheel loads



# Unconfined Flow Number (↓ or =)

- Specimens compacted in field or reheated in lab
- Three specimens per mix
- Testing Conditions- recommendations from NCHRP 09-33
- Deviator stress = 87 psi
- Temp. 7-day max. pav. temperature 20 mm below surface, 50% reliability using LTPPBind, Version 3.1.



# HMA Flow Number Results

Project	Route	Mix Heating	FN
Baker, MT	Route 322	Reheated	98
Rapid River, MI	CR-513	Reheated	199
Casa Grande, AZ	SR 84	No	61
Jefferson Co., FL	SR 30	No	414
		Reheated	231
Queens, NY	Little Neck Pkwy	No	291
Munster, IN	Calumet Ave.	No	561
Walla Walla, WA	US-12	No	332
		Reheated	426
Centreville, VA	I-66	Reheated	1855

*HMA Fn Criteria  
NCHRP Rpt. 673  
Table 8-20*

Traffic, MESALs	Min. Flow No.
<3	NA
3 to <10	53
10 to <30	190
> 30	740

# WMA Flow Number Results

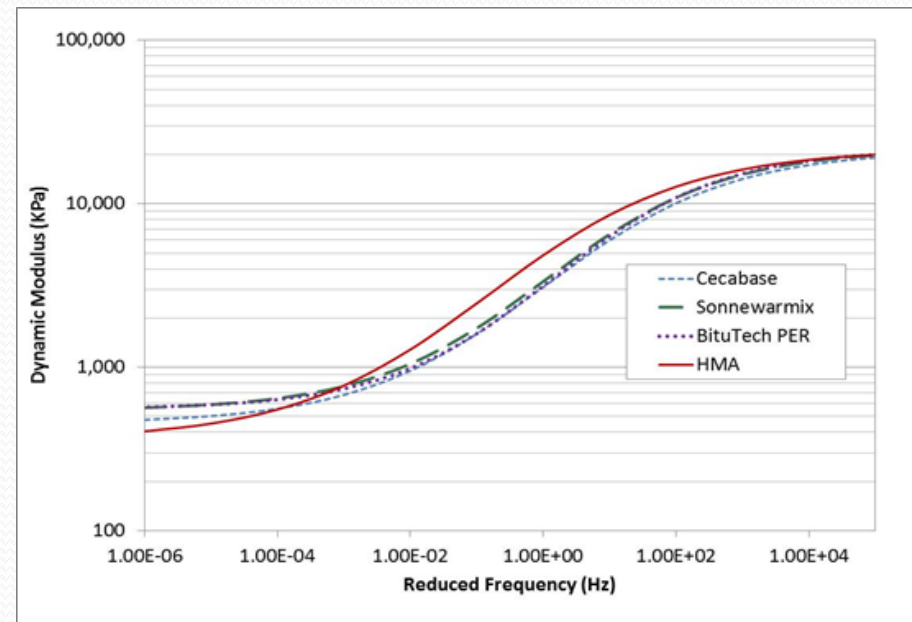
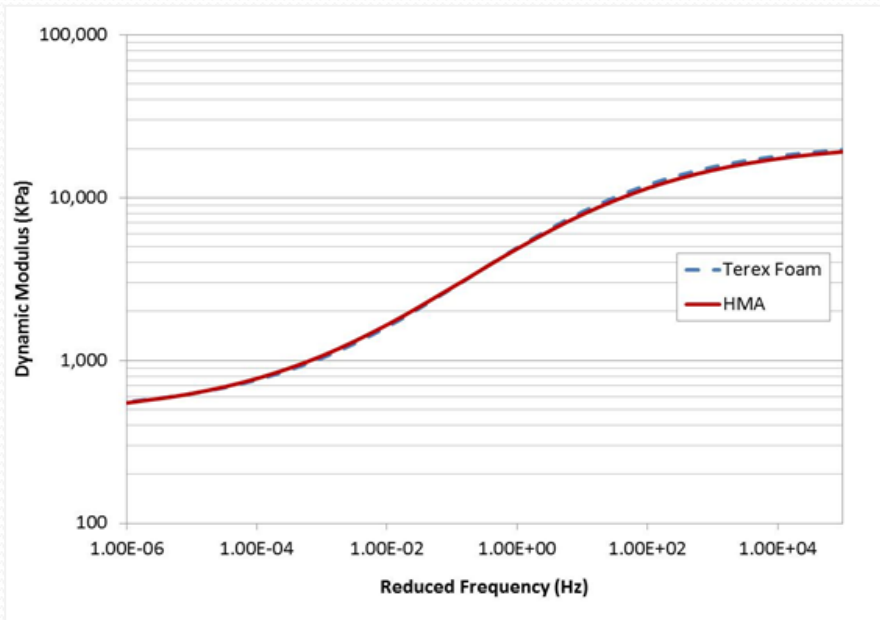
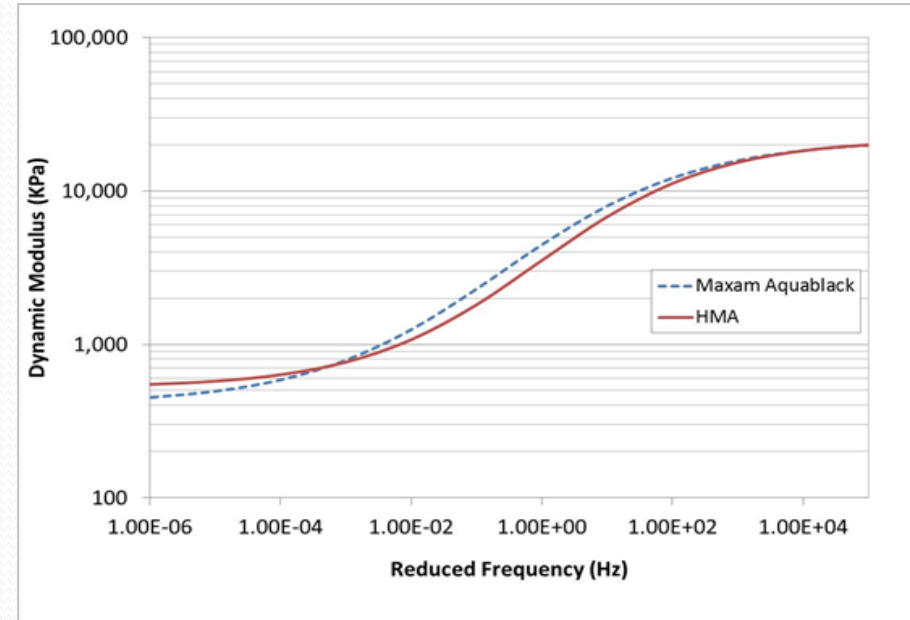
Project	Route	Mix Heating	WMA Additive	FN
Baker, MT	Route 322	RH	Evotherm DAT	58
Rapid River, MI	CR-513	RH	Advera	60
		RH	Evotherm 3G	65
Casa Grande, AZ	SR 84	No	Sasobit	46
Jefferson Co., FL	SR 30	RH	Terex Foam	127
		No	Terex Foam	157
Queens, NY	Little Neck Pkwy	No	Cecabase	115
		No	SonneWarmix	123
		No	BituTech PER	128
Munster, IN	Calumet Ave.	No	Evotherm 3G	177
		No	Gencor Foam	217
		No	Heritage Wax	314
Walla Walla, WA	US-12	No	Maxam Aquablack	200
		RH	Maxam Aquablack	227
Centreville, VA	I-66	RH	Astec DBG	439

*NCHRP 9-43 Mix Design Criteria*

Traffic, MESALs	Min. Flow No.
<3	NA
3 to <10	30
10 to <30	105
> 30	415

# Dynamic Modulus ( $\downarrow$ or =)

- AASHTO PP 61-10
- For most projects  $E^*$  of WMA lower than those of corresponding HMA



# Field Performance Evaluation Procedure

- Three 200-foot sections per mix
- Three 6" dia. cores from in right wheelpath, and four 6" dia cores from in between wheelpaths
- Cores used to determine the in-place density indirect tensile strengths, specific gravity, gradation, asphalt content, and the true binder grade for each mix.



# Field Performance-Existing Projects

Project	Mix	Rutting (mm)	Cracking (ft)
St. Louis, MO (5years 5months)	<b>HMA</b>	<b>1.9</b>	<b>628</b>
	Sasobit	0.8	1092
	Evotherm ET	2.4	1035
	Aspha min-Zeolite	2.4	1418
Iron Mtn., MI ( 4years 9months)	<b>HMA</b>	<b>1.4</b>	<b>13</b>
	Sasobit	0	46
George, WA (4 years)	<b>HMA</b>	<b>5.6</b>	<b>81</b>
	Sasobit	6	12
Silverthorne, CO (3years 2months)	<b>HMA</b>	<b>6</b>	<b>26</b>
	Advera	4	1
	Sasobit	6	3
	Evotherm DAT	6	18
Franklin, TN (3 years 5 months)	<b>HMA</b>	<b>0</b>	<b>36</b>
	Advera	0.5	143
	Astec DBG	0.4	58
	Evotherm DAT	0	86
	Sasobit	0	289
Graham, TX (2 years 6 months)	<b>HMA</b>	<b>0</b>	<b>58</b>
	Astec	0	82

# Field Performance-New Projects

Project	Mix	Rutting (mm)	Cracking (ft)
Walla Walla, WA	<b>HMA</b>	<b>1</b>	<b>0</b>
	Maxam	0	0
Centreville, VA	<b>HMA</b>	<b>0</b>	<b>0</b>
	Astec DBG	0	0
Rapid River, MI	<b>HMA</b>	<b>0</b>	<b>0</b>
	Evotherm 3G	0	2
	Advera	0	2
Baker, MT	<b>HMA</b>	<b>0.4</b>	<b>0</b>
	Evotherm DAT	0.2	0
Munster, IN	<b>HMA</b>	<b>0</b>	<b>7</b>
	Gencor Foam	0	14
	Heritage Wax	0	0
Jeff. Co., FL,	<b>HMA</b>	<b>1.9</b>	<b>0</b>
	Terex Foam	2.4	0
Queens, NY	<b>HMA</b>	<b>1</b>	<b>29</b>
	Cecabase	0.6	66
	SonneWarmix	0	17
	BituTech PER	1.2	17

# Summary Findings

- Recovered binders from field mixes -WMA binders had aged slightly less than HMA binders
- Recovered binders 1-2 year cores - true grades of HMA and WMA not substantially different, very little or no stiffening from the time of construction.
- Statistical analyses indicate that the dynamic moduli of WMA are lower than HMA mixtures in most cases
- FN results for WMA mixes lower than HMA ( 2/3 of the comparisons)

# Summary Findings

- TSR test -82% of mixes passed standard 0.8 TSR criterion- 6 mixes failed- four WMA and two HMA mixes
- Hamburg tests - 59% of WMA mixes had statistically equivalent rut depths than HMA mixes, other 41% of WMA mixes had greater rut depths
- WMA sections have performed same as HMA sections with regard to rutting
- None of the field projects had any evidence of moisture damage. Cores after 1-2 years of traffic inspected for visual evidence of stripping

# Summary Finding

- Little cracking was observed. Transverse cracking was the most common type of cracks. Of the projects with transverse cracking, WMA and HMA sections generally had similar amounts
- WMA did not appear to have effect on densities under traffic. This observation was confounded by the fact that many of the WMA test sections constructed in different lanes than the HMA sections



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